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1. Your reference	615GB
2. Patent application number *(The Patent Office will fill in this part)*	0400144.2 - 6 JAN 2004
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Renishaw plc New Mills Wotton-under-Edge Gloucestershire, GL12 8JR
Patents ADP number *(if you know it)*	2691002
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4. Title of the invention	Inspection System
5. Name of your agent *(if you have one)*	R D Cavill et al
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Renishaw plc, Patent Department New Mills Wotton-under-Edge Gloucestershire GL12 8JR
Patents ADP number *(if you know it)*	2691003

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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))*	Yes

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INSPECTION SYSTEM

This invention relates to a system for the inspection of artefacts, in particular but not exclusively to a system employed with a machine tool and to inspection by means of a measurement device such as a measurement probe.

Conventionally, a measurement probe is used on a machine tool in a so-called touch trigger mode i.e. moving the probe so as to touch an artefact and using a touch trigger signal. The signal is usually routed through an input of the machine tool's controller (NC) known as the skip line. This skip signal is a simple on/off signal that can be caused to interrupt the NC and to record the machine's position (x, y and z readings) at the instant the skip signal was issued. Thus data indicative of the probe"s position can be obtained. Whilst this system is adequate for most purposes it relies on very repeatable probe system triggering and machine velocity control, and the NC is often not capable of any significant processing of the recorded position data.

If many data points are required, for example for determining the correctness of a contour, then the touch trigger process described above can be time consuming.

In US Patent No. 5,428,548 a probe is used to feel around the artefact on a machine tool. Inputs from a scanning probe are fed to a PC which instructs the machine tool's NC to move to another position. Each time the probe is moved another set of data from the

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probe is taken the PC has to wait until the machine tool has stopped before the probe data is logged. In this way a data set of probe measurements are produced which can be associated with assumed machine tool movements. There is no feedback to the PC to confirm the machine's position. The actual position of the machine tool is assumed to be correct following position instructions issued by the PC to the NC. There is a waiting period to give time for the machine to finish moving.

In a known commercial system by Lemoine Multinational Technologies, there is provided a path scanning system which provides part form data which is associated with a machine position. This known system appears to obtain its machine position data by tapping into the so-called servo control loop, which allows the controlling software to obtain tool position data. This position data together with probe data can be combined but there is no way of confirming that the two sets of data were truly taken at exactly the same time.

The present invention provides an inspection system including a method for synchronising data from a measurement device with data from a machine tool, comprising the steps of:

issuing a signal at a plurality of instants;

recording a first set of data relating to the position of the machine at each of the instants; and

recording a second set of data from the measurement device relating to measurements of the device at each of the instants.

Preferably the signals at each of the instants is a

synchronisation signal which may issue to or from a machine tool controller. The synchronisation signal may be used to identify the real time at which each of the members of the first and second sets of data of the machine tool and measurement device were recorded in order that the position data and the measurement data can be combined with the same synchronisation signal. The combination may take place after the recording.

Thus the invention further provides for the step of combining the first data set with the second data set such that each element of the two sets are associated with the same synchronisation signal.

Preferably the method further provides the step of monitoring at regular intervals the measurement device. This may be done more frequently than the occurrences of the plurality of synchronisation signals. In this way only selected data may be recorded to the second set and/or the data may be manipulated prior to its recordal.

The present invention provides also an inspection system including apparatus for synchronising data from a measurement device with data from a machine tool, the apparatus comprising:

means for issuing a signal at a plurality of instants;

means for recording a first set of data relating to the position of the machine at each of the instants; and

means for recording a second set of data from the measurement device relating to measurements of the device at each of the instants.

The inspection system according to another aspect of the invention includes also apparatus comprising a measurement device for use on a machine tool and for generating measurement data, a machine tool control device operable to move the machine tool and to generate data relating to the position of the machine tool, a means for producing a plurality of synchronisation signals, software for collecting data from the measurement device and machine tool control device and for associating the data from the measurement device with the data from the machine tool.

Preferably synchronisation signals are issued at a time related to the time that position data or measurement data is generated. The synchronisation signal may be used to label both measurement and position data generated at the time the synchronisation signal was issued.

Alternatively the synchronisation signal may be issued from a source other than the machine tool control.

The invention will now be described with reference to the drawings, wherein the Figure shows one embodiment of a measurement system according to the invention.

The Figure shows a machine tool 10 having a control device NC 20. The NC is used to control all functions of the machine tool. Shown in the drawing are servo control and position feedback lines 30. These lines are used to control x,y and z movements of the machine. A spindle S (in this instance fixed in position) can accept a measurement probe P. The probe is used to check the dimensions of workpiece W mounted to the

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machine tool as the workpiece is moved in x, y or z directions. The probe P is of a type which can produce data representing the deflection of its stylus and can produce many results per second. The stylus deflection data is transmitted to a receiver Rx 40. The NC 20 has position feedback lines which are also capable of receiving data relating to the x,y and z positions of the machine many times per second.

A PC 50 is provided which has an interface circuit 60 e.g. a PCI, PCMCIA, Ethernet or USB type. The interface is capable of receiving and buffering data from the Rx along line 62, relating to probe stylus deflections. In this embodiment line 62 also provides for sending probe instructions. The PC accepts data via line 32, relating to the positional machine tool movements. In the present embodiment the machine tool movements are directed straight to the PC, but they could be routed via interface 60.

The interface can be used to buffer data received from the probe (and from the NC if appropriate). The buffer can store the data to send to the PC later. The interface can also use immediately the data coming from the probe to monitor conditions which require action e.g. over-deflection of the probe stylus. In such an instance of over-deflection the interface could issue a signal immediately to stop or reverse the machine's movements. Machine position data gathered immediately before the stop can be used to facilitate such action.

Where the interface is in control of real time over-deflection etc monitoring, then it is possible that the PC can instruct the interface to alter conditions at

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which over-deflection etc is deemed to have occurred so that undesirable affects such as false triggering due to vibration or rapid movement of the probe are taken into account.

These two sets of data can be used by the PC to produce an accurate profile of the workpiece W. However, useful computation can be carried out only if the two sets of data can be combined. In order for this to happen the relative time at which sets of data were obtained must be known. In operation the NC collects data relating to the machine tool movement and tabulates that data in order according to a signal from an internal clock 22.

The internal clock 22 produces the synchronisation signal 24 and the interface accepts this signal. The interface too collects data relating to probe stylus deflection and the PC tabulates that data in order according to the synchronisation signal from the internal clock 22. In practice the PC can combine elements of the NC data with elements of the probe data because both are in the same order and will be in the same or related field of their respective tables.

The PC can thus carry out computation using the data from the same or related fields in each of the tabulated data from the NC and the probe.

Speed of transfer of data to the PC from the NC and interface is not significant to the measurement speed of this system. The speed of transfer of data to the PC from the NC and interface will be dependent on the data transfer rate and the size of the memory buffers

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in the NC and the interface.

Typically the system will operate in the following manner:

the NC will run a program e.g. a program for cutting a workpiece W;

the NC will run an inspection routine which includes the selection of the measurement probe P and the movement of the workpiece W past the probe along a nominal path defined by the inspection routine; and

during the routine both the position of the machine tool and the deflection of the stylus of the probe are recorded in the manner described above.

The PC can compute such things as workpiece size or form, workpiece surface finish and the assessment of scrap workpieces. Using such data it can also compute revised cutting tool paths and new feed and speed rates.

If required the interface 60 can manipulate the data from the probe P so that, for example it is retarded or advanced to match the position data 32 from the machine tool. In this way repeatable delays from the NC or measurement device can be accommodated. It is also possible to collect more data from the measurement device or NC than the other. So e.g. measurement device data 62 can be collected at 10 times the rate of the NC position data so that filtering of the measurement device data 32 can occur in the PC, resulting in better accuracy of measurement.

To avoid breakage of the probe, one or more event signals may be incorporated into the interface circuit.

Should conditions occur for example deflection of the stylus greater than a threshold then the event signals are sent to the NC along line(s) 26. Such a signal will stop the machine via a conventional skip signal so that the unexpected problem can be overcome.

The measurement device and the interface may have multiple operating modes and these modes may be selected via signals sent to the interface from the PC or from the NC e.g. the enable signal 28 which switches the measurement probe on or off. Signals from the NC may be activated by commands within the NC program.

Many variants will be apparent to the skilled addressee. The separate NC and PC illustrated may be integral. The measurement device illustrated is a measurement probe but other measurement devices can be used e.g. cameras or thermometers. The measurement device need not have wireless communication. A hard-wired arrangement is possible. The probe used is capable of generating a stream of deflection data. The probe could also be used in a touch trigger mode i.e. a predetermined stylus deflection causes just one trigger signal. Such a mode of operation may be useful e.g. when initially setting up a workpiece, when the size of the part is not known exactly. A skip signal (like the event signal described) can be used as a touch trigger signal. The x,y,z position data 32 shown might be replaced or supplemented by non Cartesian data and could be fed into the interface rather than into the PC as illustrated.

Alternatively, in touch trigger mode the data collected from the probe and from the NC can be manipulated to

give an apparent touch trigger operation e.g. by employing an algorithm which extrapolates data back to a notional zero point, allowing improved repeatability.

The synchronisation signal 24 is illustrated as originating at the NC. However the signal could come from another source, e.g. from the interface. Thus it is possible that the NC would await the synchronisation signal and produce position data related to the time at which the signal occurs. The interface would do the same or may issue a synchronisation signal when it records measurement device data, e.g. at every tenth recording of data.

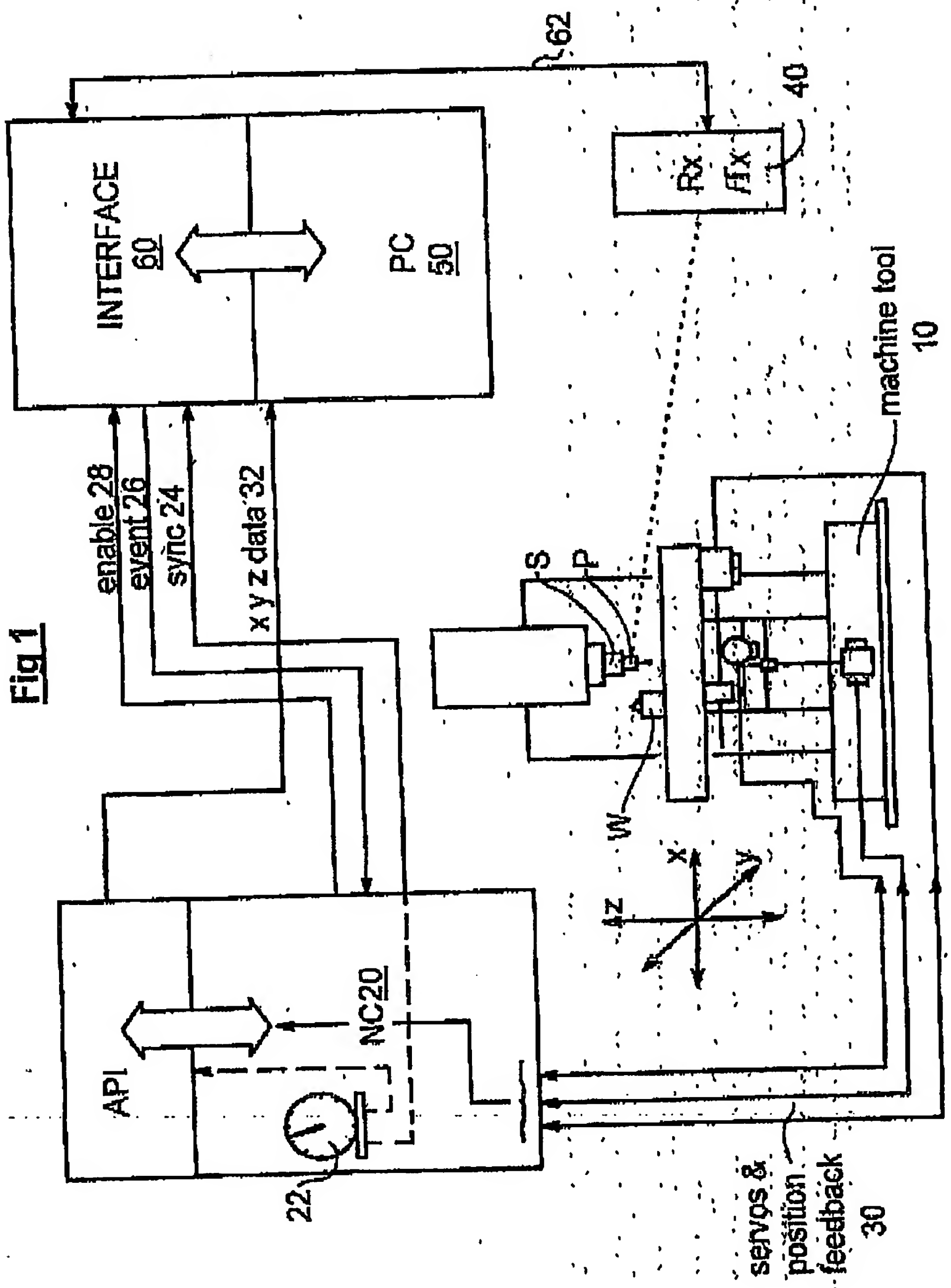

Fig 1

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